



US008441362B2

(12) **United States Patent**
Oguri

(10) **Patent No.:** **US 8,441,362 B2**
(45) **Date of Patent:** **May 14, 2013**

(54) **MOISTURE DETECTION LABEL, MOISTURE DETECTION DEVICE, MOISTURE DETECTION METHOD, POWER SHUTOFF METHOD, AND ELECTRONICS DEVICE**

(58) **Field of Classification Search** None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,297,686	A	10/1981	Tom	
4,970,122	A	11/1990	Palanisamy	
4,972,179	A	11/1990	Akiba	
5,286,415	A *	2/1994	Buckley et al.	252/502
6,175,310	B1 *	1/2001	Gott	340/605

FOREIGN PATENT DOCUMENTS

JP	3-199954	A	8/1991
JP	7-065948	B2	7/1995
JP	2574924	B2	10/1996
JP	2000-019136	A	1/2000
JP	2000-162081	A	6/2000
JP	2001-119459	A	4/2001
JP	2002-082080	A	3/2002
JP	2002-111838	A	4/2002
JP	2003-59467	A	2/2003
JP	2003-283619	A	10/2003
JP	2004-120849	A	4/2004

* cited by examiner

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(57) **ABSTRACT**

Provided is a moisture detection device including: a moisture detection label that has at least a pair of detection terminals and a pattern, the detection terminals being provided on a base material with an insulated front surface, the pattern being provided on the surface of the base material and formed between the detection terminals with water-dispersible and conductive paint; and detection circuit which detects an electrical connection state between the detection terminals.

30 Claims, 16 Drawing Sheets

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(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** **13/443,432**

(22) **Filed:** **Apr. 10, 2012**

(65) **Prior Publication Data**

US 2012/0218673 A1 Aug. 30, 2012

Related U.S. Application Data

(63) Continuation of application No. 11/203,244, filed on Aug. 15, 2005, now Pat. No. 8,242,919.

(30) **Foreign Application Priority Data**

Aug. 16, 2004 (JP) 2004-236541

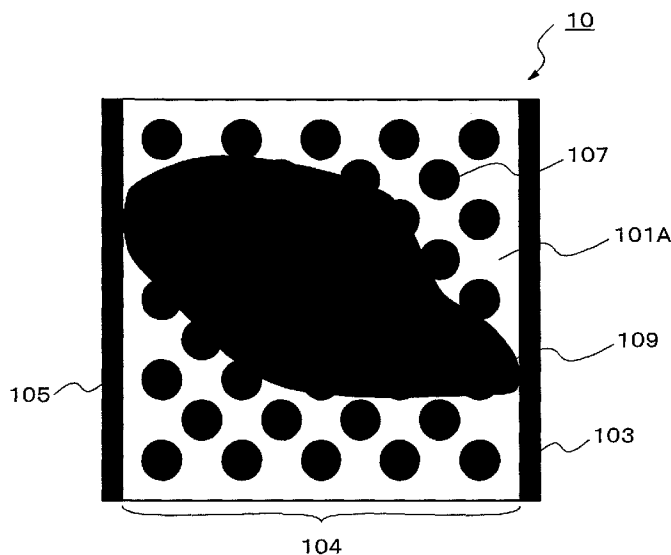
(51) **Int. Cl.**

G08B 21/00 (2006.01)

G08B 21/20 (2006.01)

(52) **U.S. Cl.**

USPC 340/605; 428/343; 428/209; 428/354;
428/349; 73/53.01; 73/40; 73/763; 73/865.9;
204/403.14; 252/502; 340/604; 340/679;
340/618



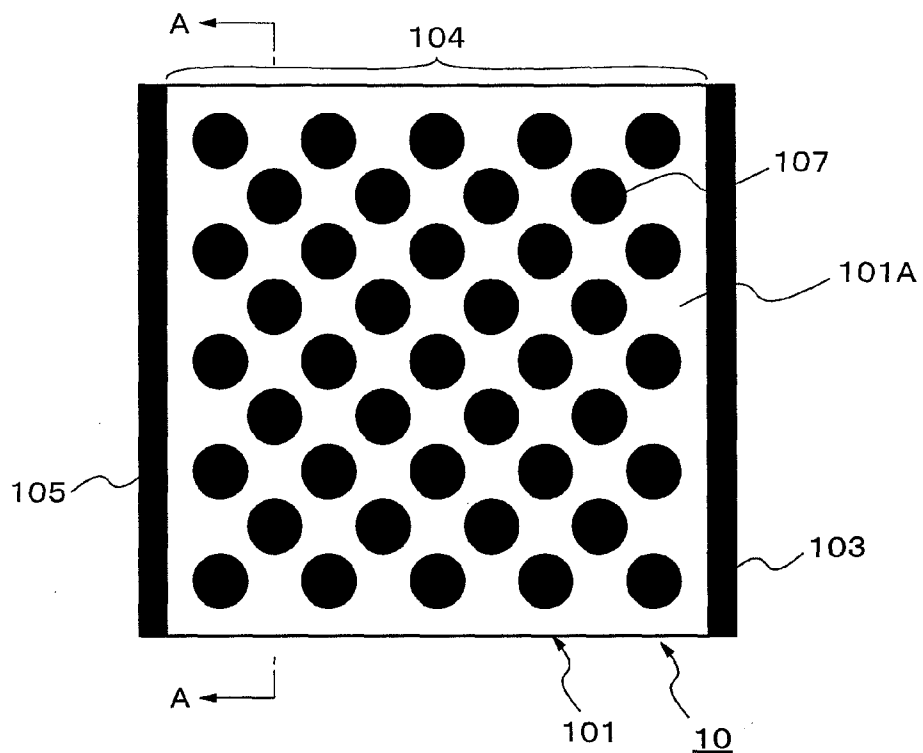


FIG.1

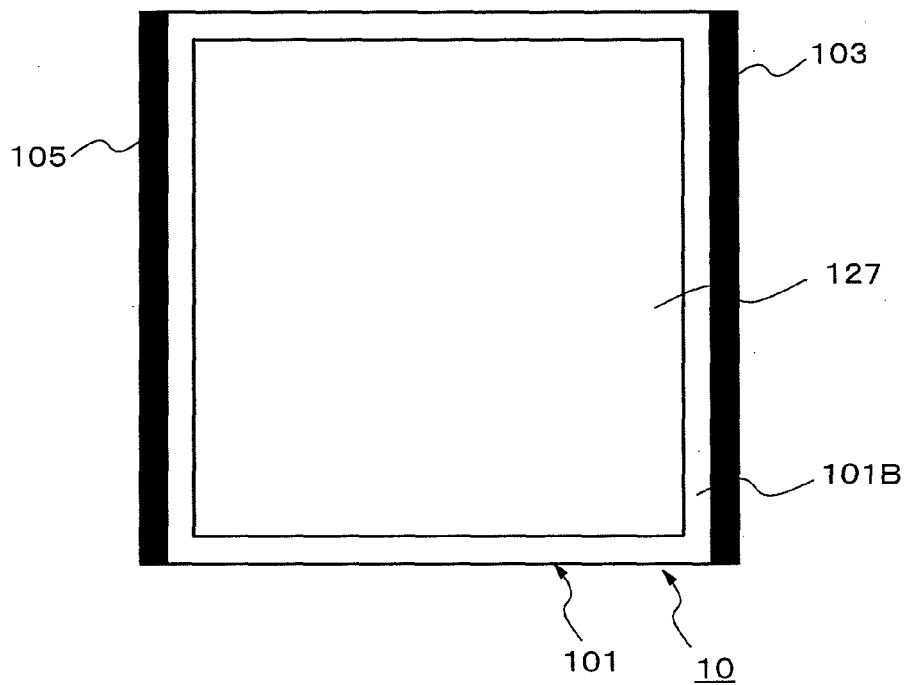


FIG.2

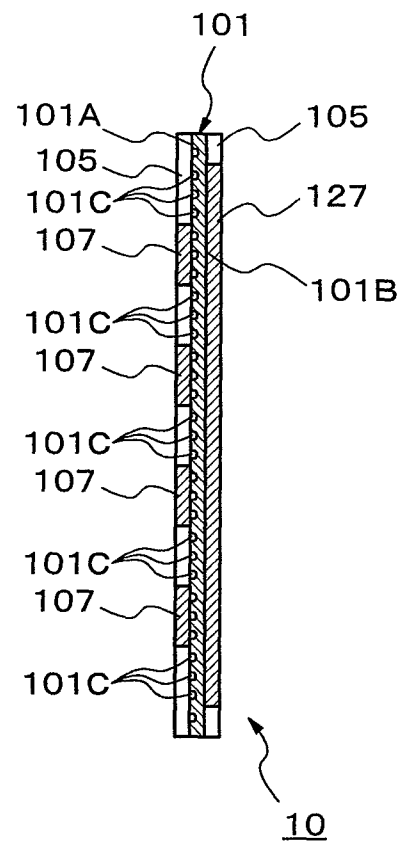


FIG.3



FIG. 4

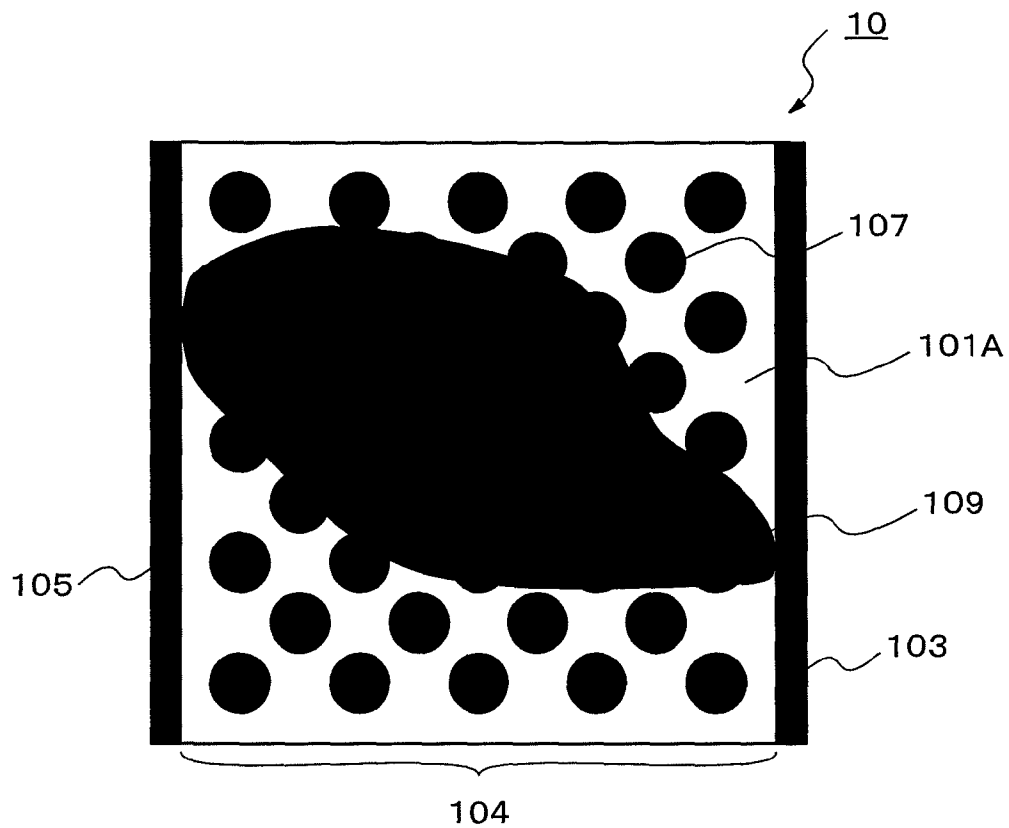


FIG. 5



FIG.6

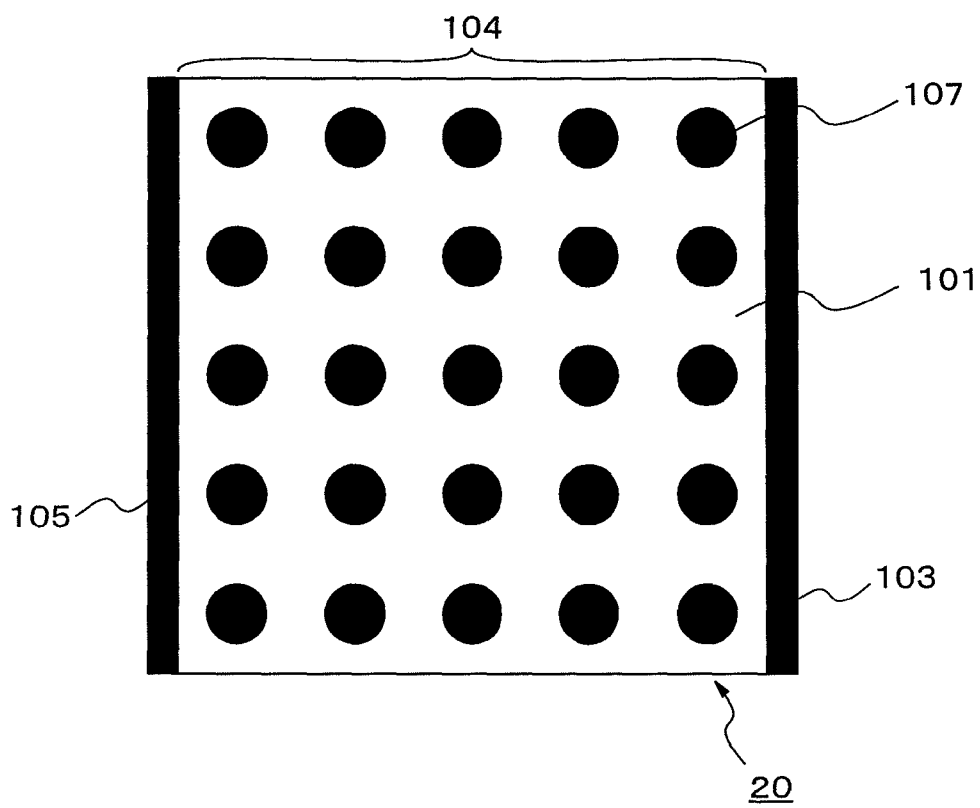


FIG.7

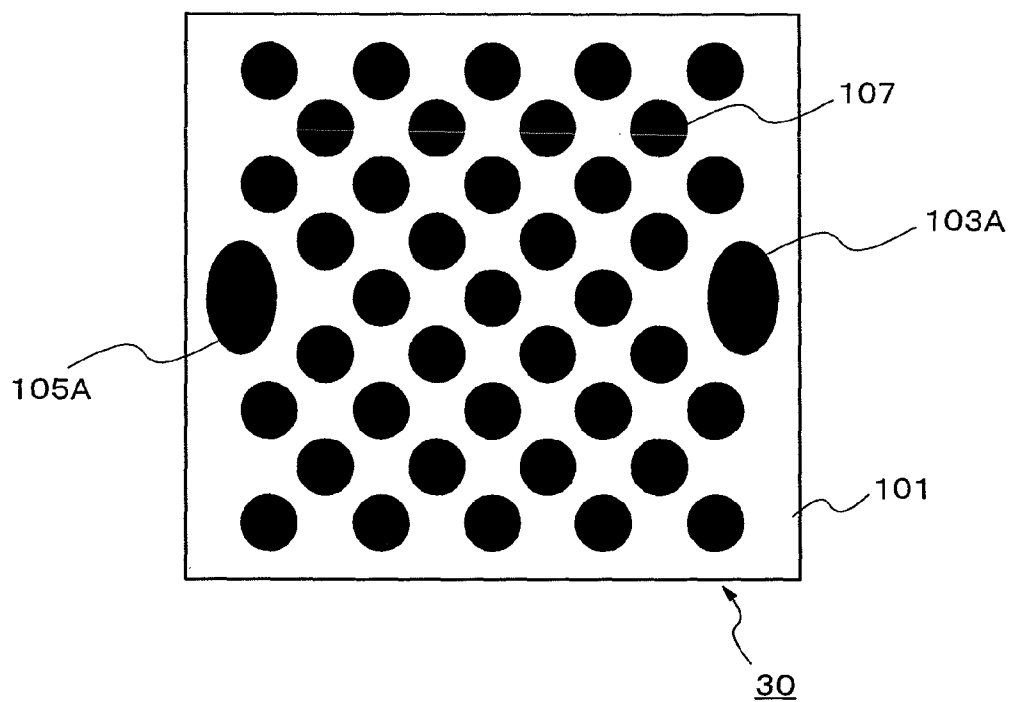


FIG. 8

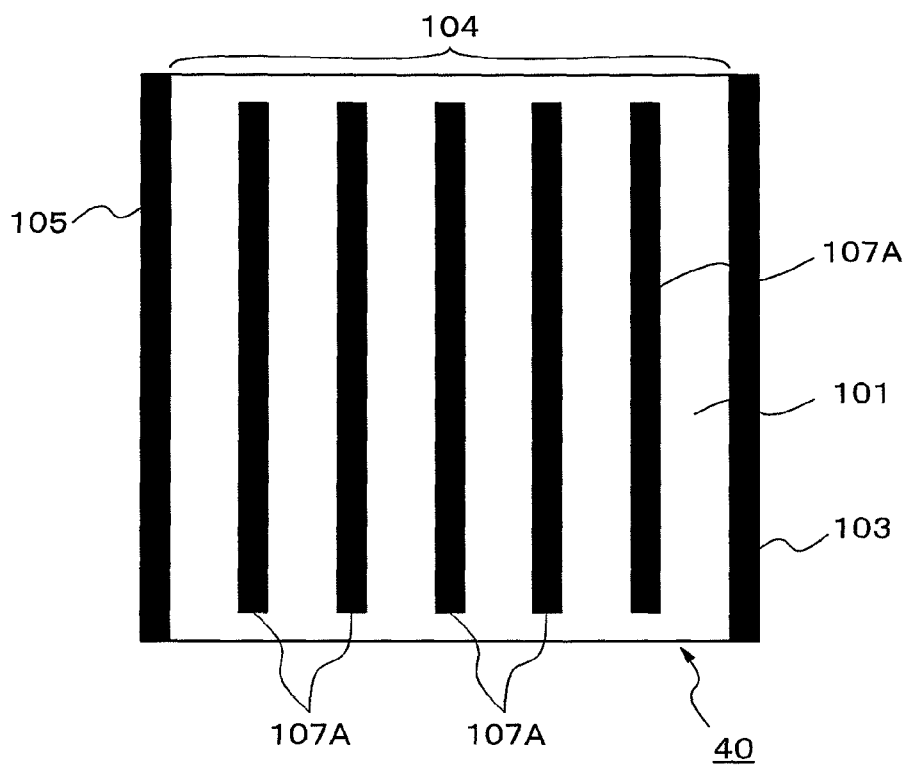


FIG. 9

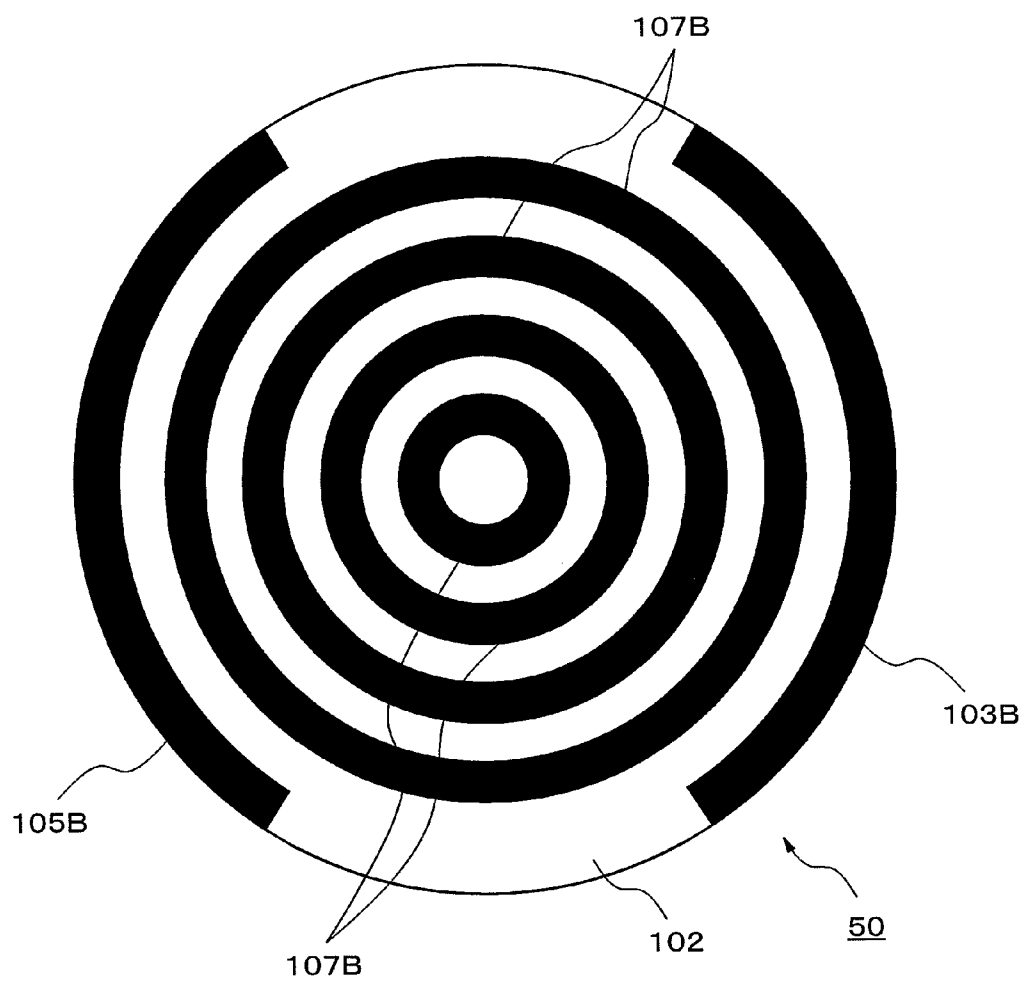


FIG.10

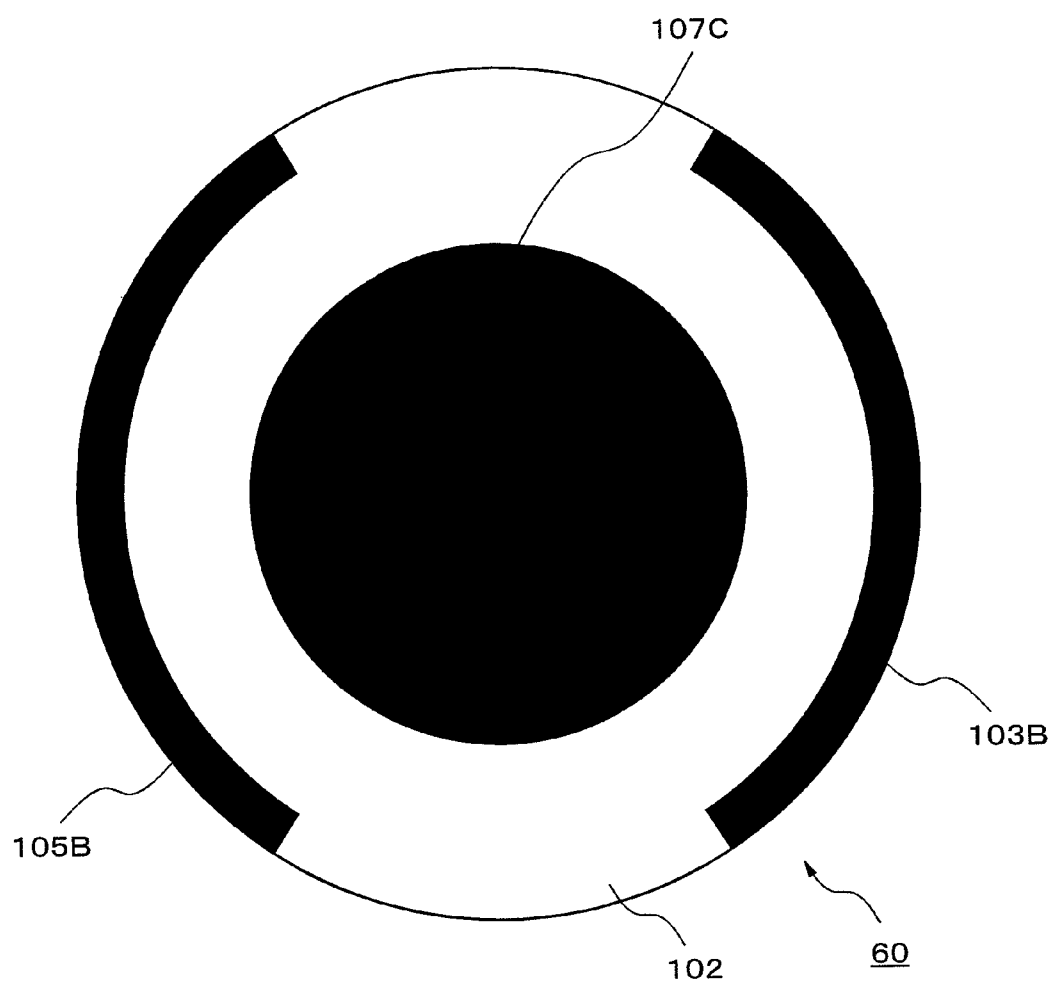


FIG.11

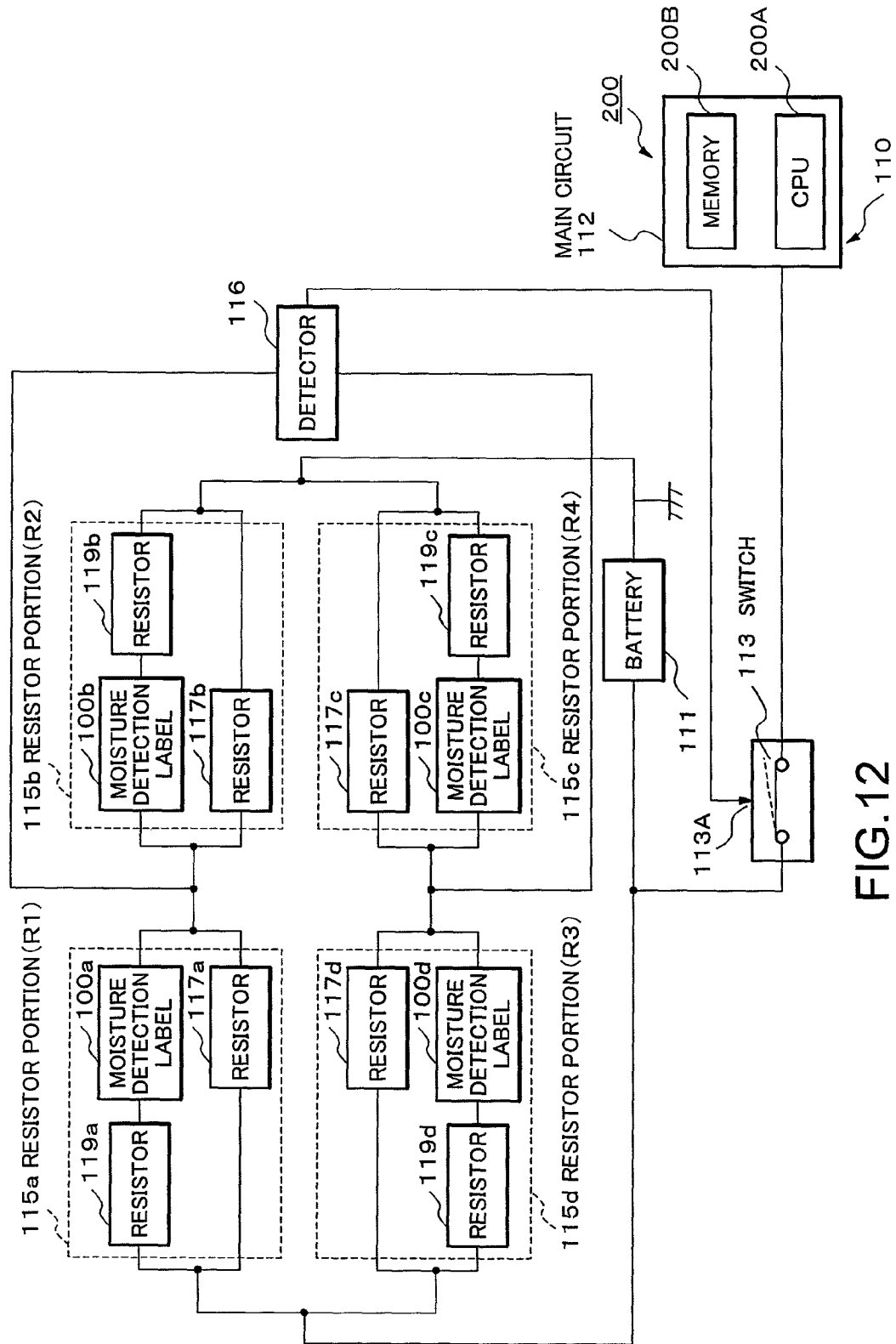


FIG.12

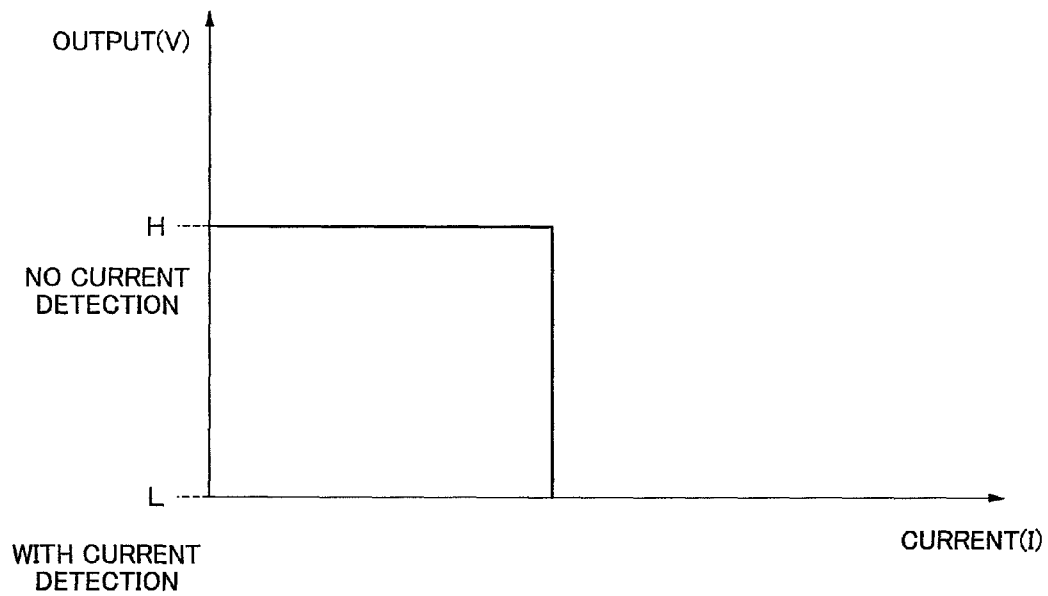


FIG.13

CONTROL TERMINAL	H	L
SWITCH	ON	OFF

FIG.14

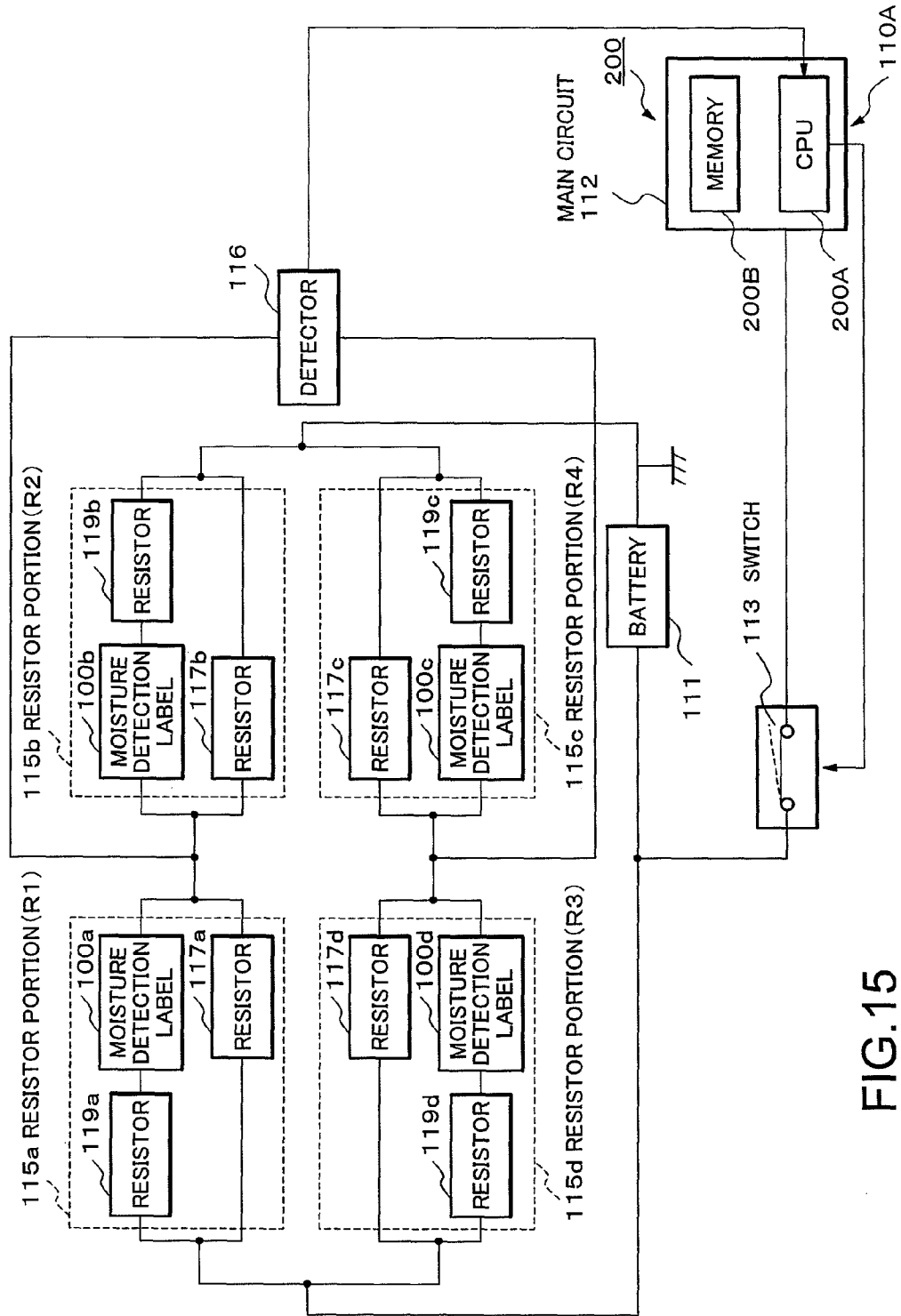


FIG.15

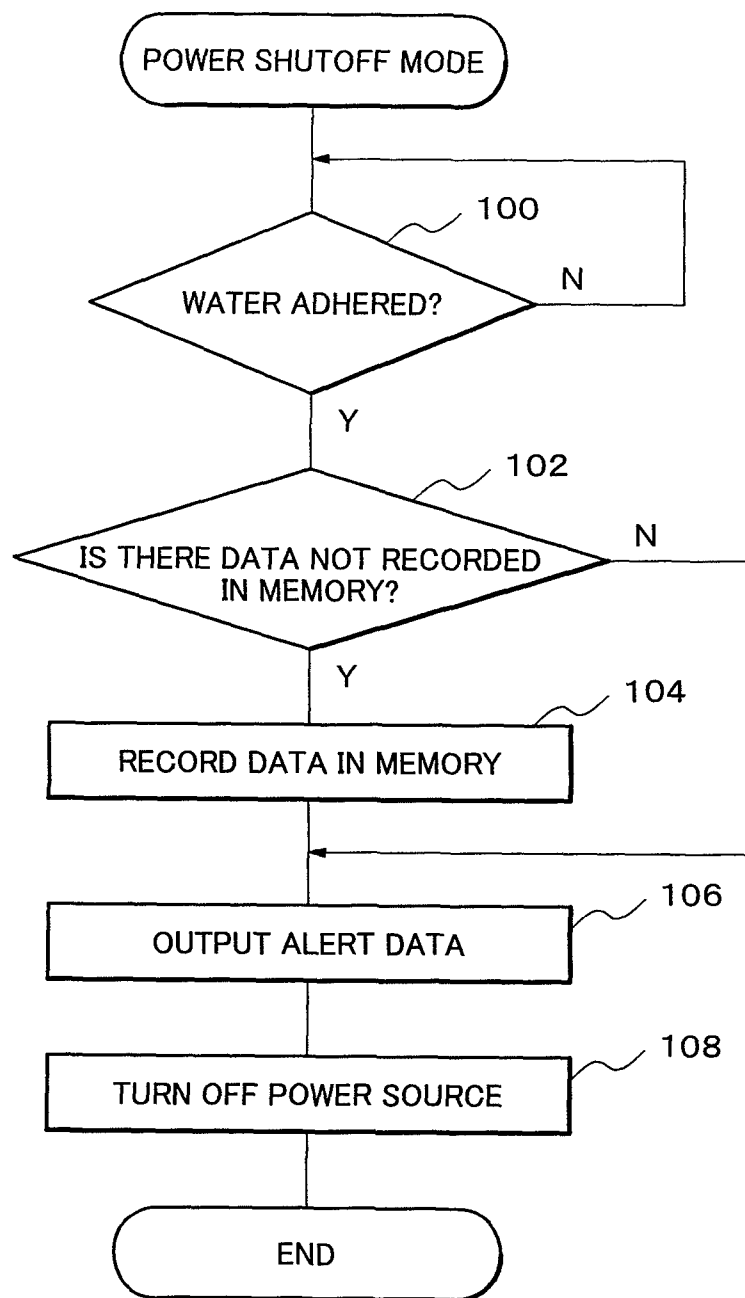


FIG.16

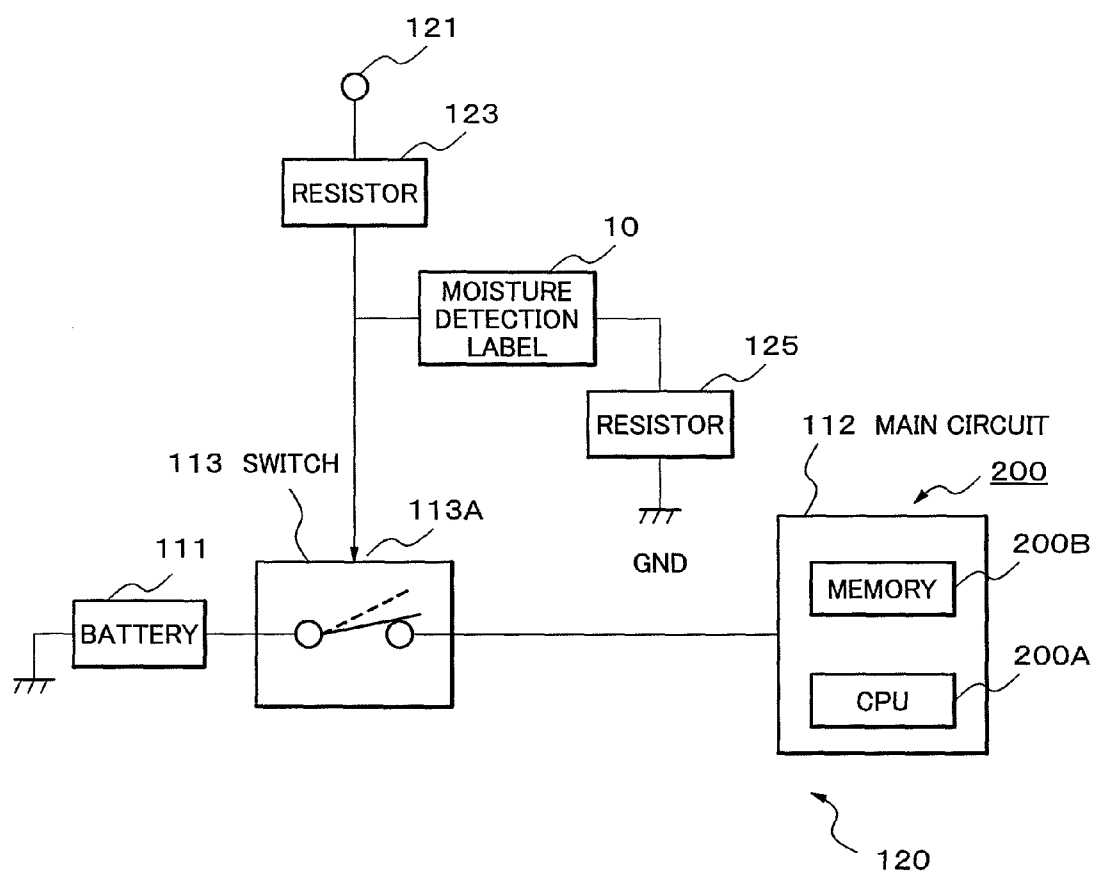


FIG.17

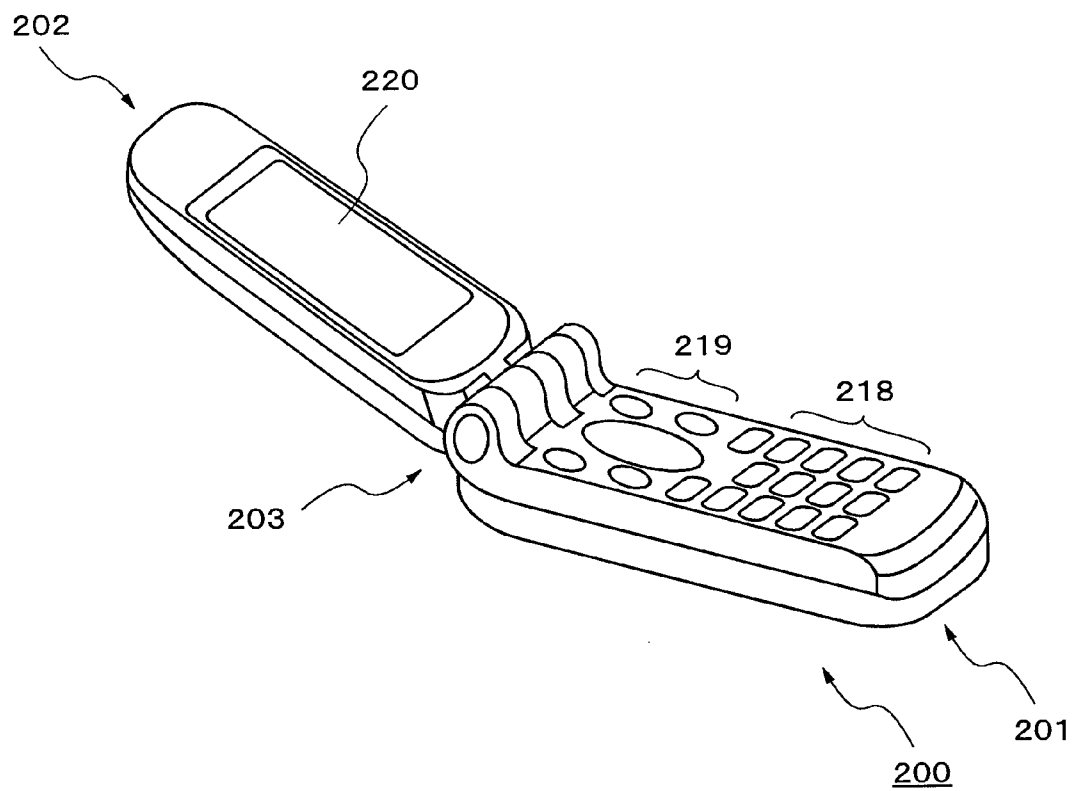


FIG.18

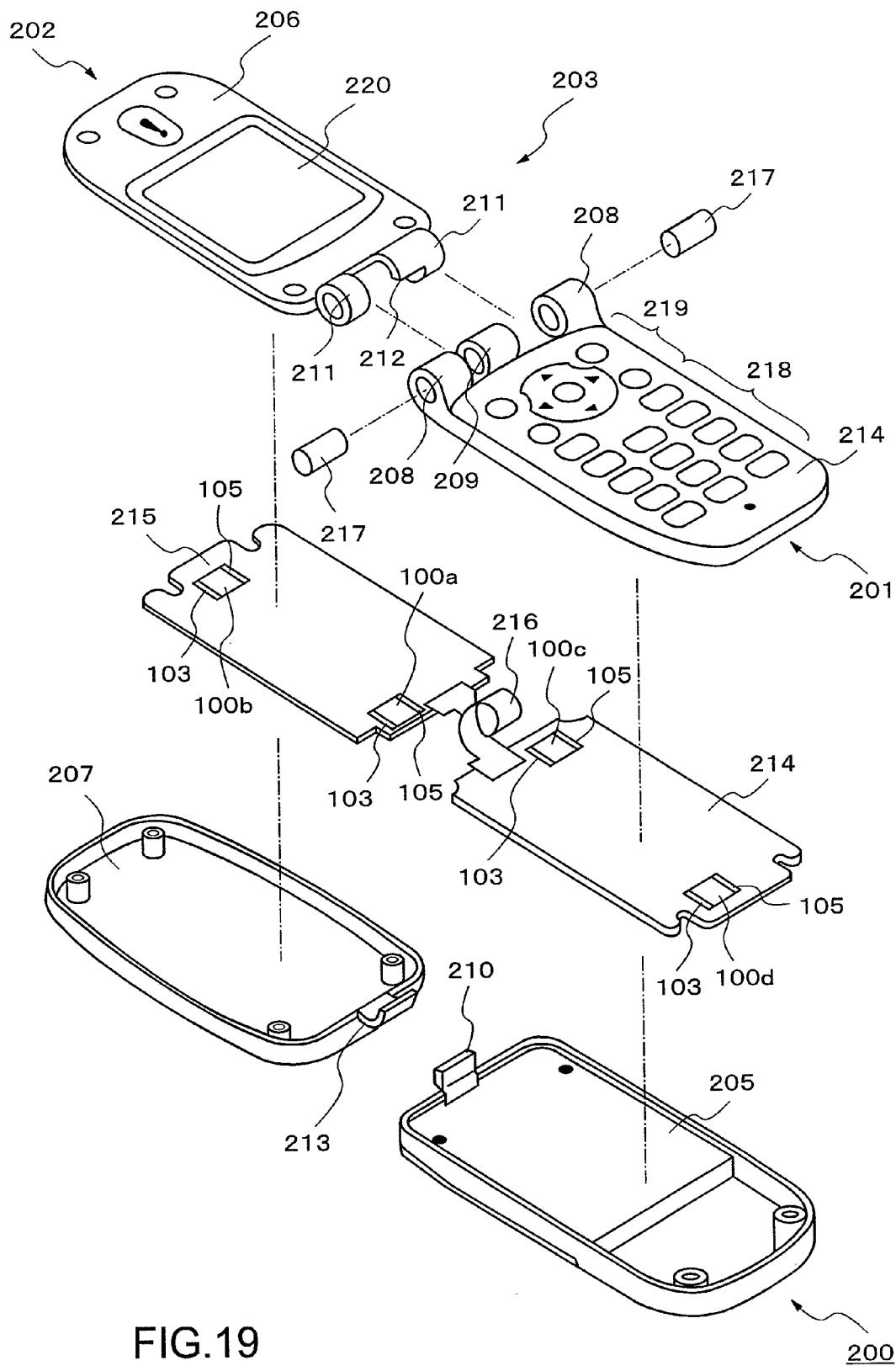


FIG.19

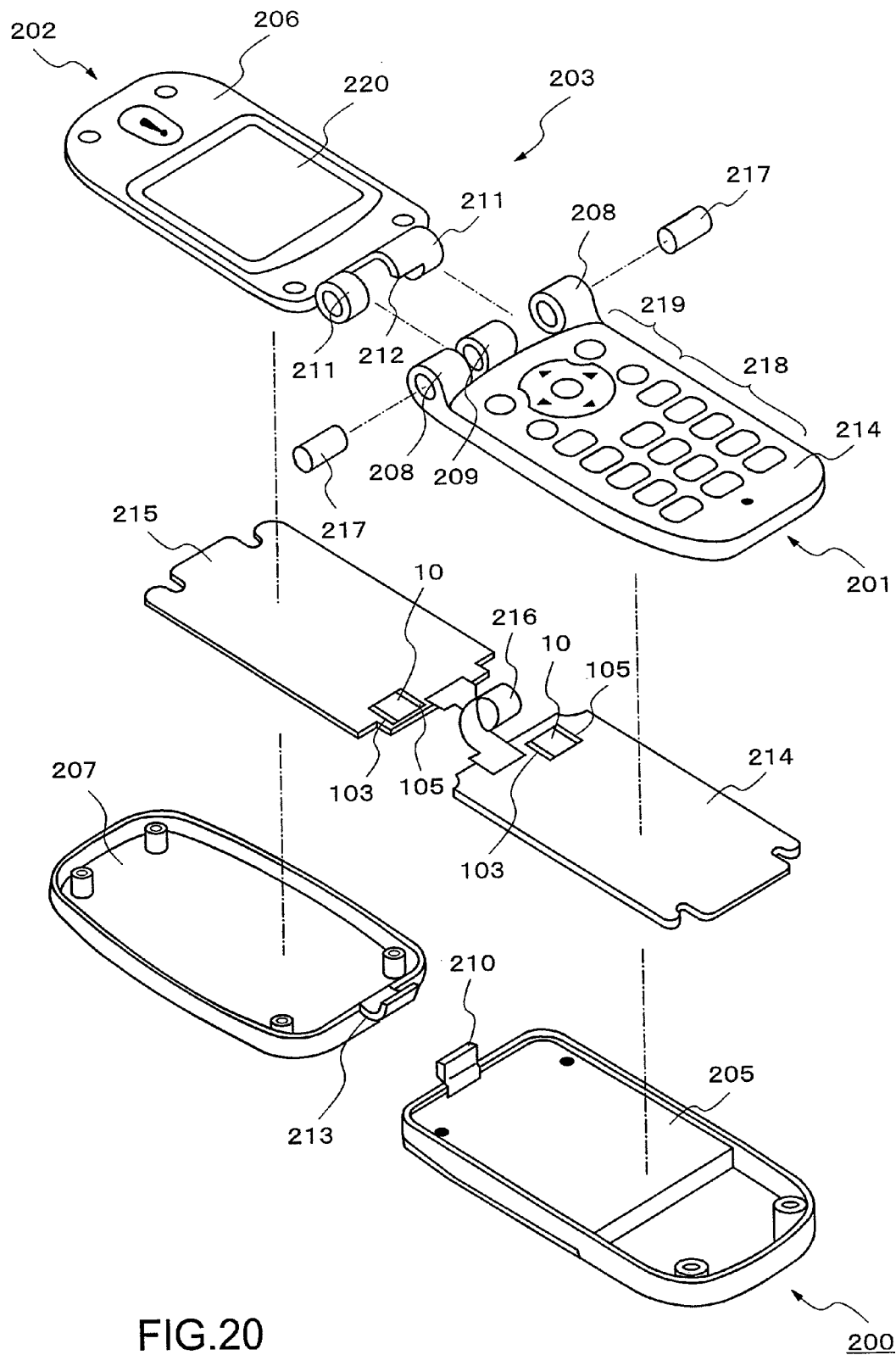


FIG.20

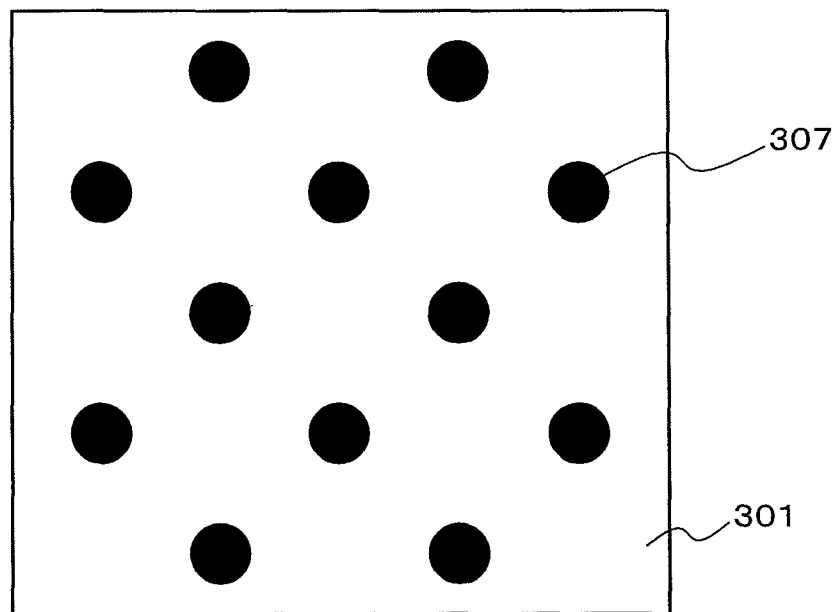


FIG. 21

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**MOISTURE DETECTION LABEL, MOISTURE
DETECTION DEVICE, MOISTURE
DETECTION METHOD, POWER SHUTOFF
METHOD, AND ELECTRONICS DEVICE**

**CROSS REFERENCE TO RELATED
APPLICATIONS**

This application is a continuation of U.S. patent application Ser. No. 11/203,244 filed Aug. 15, 2005, now U.S. Pat. No. 8,242,919, which claims priority to Japanese Patent Application No. 2004-236541, filed Aug. 16, 2004, the contents of all of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a moisture detection label, a moisture detection device, a moisture detection method, a power shutoff method, and an electronics device. In particular, the present invention relates to a moisture detection label, a moisture detection device, a moisture method, a power shutoff method, and an electronics device, each used for detecting an intrusion of a liquid into a device main body such as a portable terminal.

2. Description of the Related Art

As regards electronics devices such as cell phones, there has been proposed, for example, an electronics device having judgement label provided for detecting an intrusion of a liquid or the like into a device main body (see JP 2003-283619 A). The judgement label, as shown in FIG. 21, is made of a plastic sheet 301 on which circle patterns 307 are printed in pattern, for example, by red water-based ink. When a water droplet adheres on the circle patterns 307, the ink contained in the circle patterns 307 dissolve in the water to spread out, whereby adhesion of water can be visibly recognized.

However, according to the judgement label disclosed in JP 2003-283619 A, a user does not notice the adhesion of water unless visually identifying the label, which may lead to a case where the user keep using the cell phone. In this case, components of the cell phone are continuously supplied with power, so there is a fear that a short circuit occurs, for example.

In addition, cell phones in recent years store important data including personal information in their memories. For this reason, it is necessary to cause the cell phones to store data as soon as possible, as well as to prevent beforehand a malfunction from being caused in the cell phone due to exposure to water.

SUMMARY OF THE INVENTION

In view of the foregoing and other exemplary problems, drawbacks, and disadvantages of the conventional structures, an exemplary feature of the present invention is to provide a moisture detection label, a moisture detection device, a moisture detection method, a power shutoff method, and an electronics device.

A first object of the present invention is to provide a moisture detection label, a moisture detection device, a moisture detection method, and an electronics device, each used for reliably detecting adhesion of water eliminating a need for a visual observation of a judgment label by a user.

A second object of the present invention is to provide a power shutoff method and an electronics device, with which a malfunction due to exposure to water can be prevented beforehand.

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An exemplary moisture detection label for achieving the first object of the present invention includes: a base material having an insulated front surface, at least a pair of detection terminals provided on the base material, a pattern provided on the surface of the base material and formed between the detection terminals, the pattern containing water-dispersible and conductive paint.

An exemplary moisture detection device for achieving the first object of the present invention includes: a moisture detection label that has at least a pair of detection terminals and a pattern, the detection terminals being provided on a base material with an insulated front surface, the pattern being provided on the surface of the base material and formed between the detection terminals with water-dispersible and conductive paint; and detector that detects an electrical connection state between the detection terminals of the moisture detection label.

An exemplary moisture detection method for achieving the first object of the present invention, (i) uses a moisture detection label that includes at least a pair of detection terminals and a pattern, the detection terminals being provided on a base material having an insulated front surface, the pattern containing water-dispersible and conductive paint and being formed between the detection terminals, in which (ii) the paint that swells by absorbing moisture adhered disperses toward the detection terminals, to thereby detect an electrical connection state caused between detection terminals through the paint.

An exemplary electronics device for achieving the first object of the present invention includes: a device main body having power source; a moisture detection label that is provided on the device main body, and has at least a pair of detection terminals and a pattern, the detection terminals being provided on a base material with an insulated front surface, the pattern being provided on the surface of the base material and formed between the detection terminals with a water-dispersible and conductive paint; and detector that is provided on the device main body and detects an electrical connection state between the detection terminals of the moisture detection label.

Also, an exemplary electronics device for achieving the second object of the present invention includes: a device main body having power source; a moisture detection label that is provided on the device main body and has at least a pair of detection terminals and a pattern, the detection terminals being provided on a base material with an insulated front surface, the pattern being provided on the surface of the base material and formed between the detection terminals with a water-dispersible and conductive paint; detector that is provided on the device main body and detects an electrical connection state between the detection terminals of the moisture detection label; and power shutoff means for shutting off power based on the electrical connection state detected by the detector.

An exemplary power shutoff method for achieving the second object of the present invention, (i) is used in a moisture detection label that includes at least a pair of detection terminals and a pattern, the detection terminals being provided on a base material having an insulated front surface, the pattern containing water-dispersible and conductive paint and being formed between the detection terminals, (ii) detects an electrical connection state between the detection terminals, and (iii) shuts off power in a case where it is detected that the detection terminals are electrically connected.

In the present invention, for example, when moisture adheres to the surface of the base material, conductive paint is dispersed to electrically connect between the detection terminals.

nals. Accordingly, it is possible to reliably detect adhesion of water by, for example, causing the moisture detection device to detect an electrical connection state between the detection terminals. Note that the paint is dispersed over the surface of the base material, whereby adhesion of water can be visually detected.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a plan view showing a first exemplary embodiment of a moisture detection label according to the present invention;

FIG. 2 shows an under surface of the moisture detection label shown in FIG. 1;

FIG. 3 is a cross-sectional view taken along the line A-A in FIG. 1;

FIG. 4 is an equivalent circuit diagram schematically showing the moisture detection label shown in FIG. 1 as an electronic circuit;

FIG. 5 is a plan view showing a state in which paint contained in patterns is dispersed in the moisture detection label in FIG. 1;

FIG. 6 is an equivalent circuit diagram schematically showing the moisture detection label shown in FIG. 5 as an electronic circuit;

FIG. 7 is a plan view showing a second exemplary embodiment of the moisture detection label according to the present invention;

FIG. 8 is a plan view showing a third exemplary embodiment of the moisture detection label according to the present invention;

FIG. 9 is a plan view showing a fourth exemplary embodiment of the moisture detection label according to the present invention;

FIG. 10 is a plan view showing a fifth exemplary embodiment of the moisture detection label according to the present invention;

FIG. 11 is a plan view showing a sixth exemplary embodiment of the moisture detection label according to the present invention;

FIG. 12 is a block diagram showing a first exemplary embodiment of a moisture detection device according to the present invention;

FIG. 13 is a graph showing a relationship between an output voltage and an amount of output power at a current detector in the moisture detection device shown in FIG. 12;

FIG. 14 is a table showing a relationship between an input voltage and a switching operation at a switch in the moisture detection device shown in FIG. 12;

FIG. 15 is a block diagram showing a second exemplary embodiment of the moisture detection device according to the present invention;

FIG. 16 is a flowchart showing a process flow of controlling power in the moisture detection device shown in FIG. 15;

FIG. 17 is a block diagram showing a third exemplary embodiment of the moisture detection device according to the present invention;

FIG. 18 is a perspective view of a first exemplary embodiment of a cell phone according to the present invention;

FIG. 19 is an exploded perspective view showing the cell phone shown in FIG. 18;

FIG. 20 is an exploded perspective view of a second exemplary embodiment of the cell phone according to the present invention; and

FIG. 21 is a plan view of a conventional judgment label.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

(Moisture Detection Label Construction)

Hereinafter, a moisture detection label **10** according to a first exemplary embodiment of the present invention is described based on FIGS. **1** to **6**. The moisture detection label includes: a substrate **101** having a front surface **101A** (including a rear surface **101B**) insulated; at least a pair of detection terminals **103** and **105** provided on the substrate **101**; and patterns **107** that are provided on the front surface **101A** and formed between the detection terminals **103** and **105**, and contain water-dispersible and conductive paint. The thin-plate-like substrate **101** is formed of an insulating resin such as polyethylene, polyethylene terephthalate, polycarbonate, or acrylonitrile-butadiene-styrene copolymer. A planar shape of the substrate **101** is square with one side length of 3 to 10 mm, for example, but may be rectangular, circular, polygonal, etc. The substrate **101** may be formed of a transparent material or a non-transparent material.

The same-shaped patterns **107** equal in shape are arranged at plural spots with their vertical lines and horizontal lines alternately shifted on the front surface **101A** of the substrate **101**. The patterns **107** are made of water-dispersible and conductive paint, examples of which include water-base conductive electrodeposition paint having a water dispersible property too. The electrodeposition paint is, for example, paint prepared by mixing a conductive material (ion) with ink. The patterns **107** are formed of paint with a color different from that of the substrate **101**. Then, the patterns **107** are two-dimensionally dispersed and arranged.

The planar shape of the substrate **101** is circular with a diameter of 0.5 to 2 mm, for example. The patterns **107** are formed, for example, by printing the electrodeposition paint on the front surface **101A** of the substrate **101** (see FIG. 3). Each of the patterns **107**, namely, the paint swells to be dispersed when moisture adheres thereto.

The tabular detection terminals **103** and **105** are arranged in pairs on opposing ends of the substrate **101**. The detection terminals **103** and **105** are formed of a conductive material such as metal including copper, or an alloy. As shown in FIG. 2, the detection terminals **103** and **105** are structured such that detection signals are output to outside from the front surface **101A** and the rear surface **101B** of the substrate **101**.

The detection terminals **103** and **105** each have the same length as the one side length of the substrate **101**, and are attached to the substrate **101** so that all the patterns **107** are located therebetween. For example, the detection terminals **103** and **105** may be fixed to the both ends of the substrate **101** as being inserted thereto. Also, the detection terminals **103** and **105** are separated across the patterns **107**.

Then, in the substrate **101**, an area between the detection terminals **103** and **105** becomes a moisture detection area **104** (see FIG. 1). Also, the front surface **101A** of the substrate **101** is formed such that the patterns **107** swelling by absorbing adhesion moisture disperse toward the detection terminal **103** or **105**. For example, as shown in FIG. 3, the front surface **101A** of the substrate **101** has plural grooves **101C** at predetermined intervals across the detection terminals **103** and **105**, thereby obtaining such effect that the electrodeposition paint dispersed by getting wet easily spread along the grooves **101C**.

Note that a shape of the grooves **101C** may be linear, curved, or polygonal. In this exemplary embodiment, the front surface **101A** of the substrate **101** may be formed flat.

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Even in this case, since the ink is dispersed upon getting wet, it spreads out without such grooves as described above on the front surface **101A**.

Further, in this exemplary embodiment, in addition to the pair of the detection terminals **103** and **105**, two detection terminals may be additionally provided. For example, the additional two detection terminals are provided on the other sides where the detection terminals **103** and **105** are not provided such that they are not connected to the detection terminals **103** and **105**. If there are four detection terminals, adhesion of water is detected quickly and reliably.

As shown in FIG. 2, a sheet **127** is arranged on the rear surface **101B** of the substrate **101**. The sheet **127** has both surfaces coated with an adhesive etc. like a two-sided tape, with which the moisture detection label **10** is affixed to a predetermined position of an electronics device.

For example, the moisture detection label **10** is manufactured as follows. A single metal plate is bent to sandwich the front and rear surfaces of the substrate **101** on both ends, constituting the detection terminal **103**. That is, the detection terminal **103** is attached along one side of the substrate **101** and the detection terminal **105** is attached along the other side thereof. Next, the electrodeposition paint is applied to predetermined spots away from the detection terminals **103** and **105** on the front surface **101A** of the substrate **101**, namely, the moisture detection area **104**, constituting the plural patterns **107** (see FIGS. 1 and 3).

Then, the sheet **127** is affixed to the rear surface **101R** of the substrate **101** (see FIGS. 2 and 3). That is, in this exemplary embodiment, the moisture detection label **10** can be easily produced. Note that the patterns **107** maybe rectangular or other shape, not necessarily being circular. The patterns are preferably circular because the wet patterns **107** easily spread (radially) in all directions.

(Moisture Detection Method)

Next, a moisture detection method using the moisture detection label **10** according to the first exemplary embodiment of the present invention is described based on FIGS. 1 and 4 to 6. In this moisture detection method, for example, the moisture detection label **10** is used which includes: at least the pair of detection terminals **103** and **105** provided on the substrate **101** having the insulated front surface **101A**; and the patterns **107** that are provided on the front surface **101A** of the substrate **101** and formed between the detection terminals **103** and **105**, and contain water-dispersible and conductive paint. The paint that swells by absorbing adhesion moisture disperses toward the detection terminals **103** and **105**. Then, electrical connection caused between the detection terminals **103** and **105** through the paint is detected.

When moisture does not adhere to the patterns **107** of the moisture detection label **10**, as shown in FIGS. 1 and 4, there is no electrical connection between the detection terminals **103** and **105**, with no current flowing therebetween.

On the other hand, when moisture adheres to the patterns **107** of the moisture detection label **10**, as shown in FIG. 5, the patterns (paint) **107** swell and disperse, thereby spreading (seeping) out to the moisture detection area **104**. The substrate **101** has the plural grooves **101C** between the detection terminals **103** and **105**, whereby the patterns (paint) **107** quickly and reliably disperse to the detection terminal **103** or **105**.

A moisture-adhered area **109** expands by the seeping patterns (paint) **107** and the conductive paint connects the detection terminals **103** and **105**. That is, as shown in FIG. 6, the detection terminals **103** and **105** are electrical connected with a resistance value of the ink. In this exemplary embodiment,

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the existence of adhesion of moisture is judged by detecting the electrical connection state between the detection terminals **103** and **105**.

Even when moisture adheres to the patterns (paint) **107**, such a case may happen that the paint do not spread across the detection terminals **103** and **105**. In this exemplary embodiment, moisture deposition at such a level that the paint does not connect the detection terminals **103** and **105** is not regarded as a water adhesion state.

In the moisture detection label **10**, when the front surface **101A** of the substrate **101** gets wet in water, the paint in the patterns seeps out from the patterns and the planer shape of the patterns **107** changes. Accordingly, as shown in FIG. 5, the planer shape of the patterns **107** changes upon moisture deposition thereon. Therefore, adhesion of water can be visually detected with ease. Also, in the moisture detection label **10**, the moisture-adhered area **109** expands when moisture adheres to the patterns **107**, to thereby electrically connect the detection terminals **103** and **105** (see FIG. 6), leading to a change in the resistance value.

Thus, water leak is electrically detected using the moisture detection label **10** in this exemplary embodiment.

Therefore, and if the moisture detection label **10** is arranged in the electronics device, adhesion of water to the electronics device can be reliably detected.

Note that in this exemplary embodiment, since the patterns **107** are arranged with their vertical lines and horizontal lines alternately shifted, when moisture adheres to the patterns (paint) **107**, paint is reliably dispersed and the moisture-adhered area **109** expands. Also, in this exemplary embodiment, the detection terminals **103** and **105** are arranged along the entire sides of the substrate **101** on the both ends. Even when moisture adheres to the patterns (paint) **107**, adhesion of water can be reliably detected.

In this exemplary embodiment, the shape of the substrate **101**, the shape or arrangement of the patterns **107** or the detection terminal **103** (**105**), or the like can be changed as appropriate.

FIGS. 7 to 11 are plan views of a moisture detection label according to second to sixth exemplary embodiments of the present invention. Note that in the second to fourth exemplary embodiments shown in FIGS. 7 to 9, parts corresponding to those of FIG. 1 are denoted by the same reference numerals and a detailed description thereof is omitted.

For example, as shown in FIG. 7, the patterns **107** of a moisture detection label **20** are arranged with their vertical lines and horizontal lines aligned. Other constructions (for example, the grooves are formed across the detection terminals), actions, and effects are the same as those of the exemplary embodiment of FIG. 1.

As shown in FIG. 8, a planer shape of detection terminals **105A** and **103A** in a moisture detection label **30** may have an elliptic shape vertically elongated. In this case, the detection terminals **105A** and **103A** are embedded in the substrate **101** while the front and rear surfaces thereof are exposed from the front and rear surfaces of the substrate **101**. Accordingly, also in the exemplary embodiment of FIG. 8, an electrical connection state between the detection terminals **105A** and **103A** can be detected from the rear surface of the substrate **101**.

Note that in the third exemplary embodiment shown in FIG. 8, the detection terminals **105A** and **103A** each arranged substantially at each of the centers of both ends of the moisture detection label **30**. Other constructions and action effects are the same as those of the exemplary embodiment of FIG. 1.

As shown in FIG. 9, a planer shape of patterns **107A** in a moisture detection label **40** may be stripes, for example. In this case, the plural patterns **107A** are arranged in parallel to

the detection terminals **103** and **105** at equal intervals. Other constructions and action effects are the same as those of the exemplary embodiment of FIG. **1**.

As shown in FIG. **10**, a planer shape of a substrate **102** in a moisture detection label **50** may be circular and a planer shape of patterns **107B** may be rings. In this case, the plural rings **107B** are arranged at equal intervals to be concentric to the center of the moisture detection label **50**.

Also, in the moisture detection label **50** of FIG. **10**, a pair of detection terminals **103B** and **105B** are made arcs along an outer periphery of the substrate **102**. According to the fifth exemplary embodiment shown in FIG. **10**, the substrate **102** has a disc shape, and therefore the moisture detection label **50** can be made smaller than the angular moisture detection labels **10**, **20**, **30**, and **40** (see FIGS. **1** and **7** to **9**). Other constructions and action effects are the same as those of the exemplary embodiment of FIG. **1**.

As shown in FIG. **11**, a planer shape of a pattern **107C** in a moisture detection label **60** may be circular, for example. Note that for the construction of the sixth exemplary embodiment shown in FIG. **11**, parts corresponding to those of FIG. **10** are denoted by the same reference numerals and a detailed description thereof is omitted in FIG. **11**.

In this exemplary embodiment, the number of the pattern **107C** can be set to one. Other constructions and action effects are the same as those of moisture detection label **50** of FIG. **10**.

(Moisture Detection Device Construction)

A moisture detection device according to a first exemplary embodiment of the present invention (see FIG. **12**) has one of the moisture detection labels **10**, **20**, **30**, **40**, **50**, and **60** shown in FIGS. **1** and **7** to **9** mounted thereto. The moisture detection labels shown in FIG. **12** are denoted by reference numeral **100** (**100a**, **100b**, **100c**, and **100d**) to be described.

A moisture detection device **110** of this exemplary embodiment includes: at least a pair of detection terminals provided on a substrate having an insulated front surface; four moisture detection labels **100** that are provided on the front surface of the substrate and formed between the detection terminals, and contain water-dispersible and conductive paint; and a current detector **116** (detection means) for detecting an electrical connection state between the detection terminals of the moisture detection labels **100**.

As shown in FIG. **12**, the moisture detection device **110** of this exemplary embodiment further includes four resistor portions **115a**, **115b**, **115c**, and **115d**, which are connected circularly. That is, the moisture detection device **110** is an example using a Wheatstone bridge.

The resistor portions **115a**, **115b**, **115c**, and **115d** have first resistors **117a**, **117b**, **117c**, and **117d**, respectively. The first resistors **117a** to **117d** have the same resistance values.

Thus, when the moisture detection labels **100** are not wet in water (specifically, a non-electrically-connected state shown in FIGS. **1** and **4**), the resistor portions **115a** to **115d** are in a balanced state due to setting (the same resistance values) of the first resistors **117a** to **117d**. Here, the balanced state of the Wheatstone bridge means a state where no current flows into the current detector **116** while the resistor portions **115a** (**R1**), **115b** (**R2**), **115c** (**R3**), and **115d** (**R4**) shown in FIG. **12** have a relation of $R1/R2=R3/R4$.

In the resistor portion **115a**, a second resistor **119a** and the moisture detection label **100a**, which are connected in series, are connected to the first resistor **117a** in parallel. In the resistor portion **115b**, a second resistor **119b** and the moisture detection label **100b**, which are connected in series, are connected to the first resistor **117b** in parallel. In the resistor portion **115c**, a second resistor **119c** and the moisture detec-

tion label **100c**, which are connected in series, are connected to the first resistor **117c** in parallel. In the resistor portion **115d**, a second resistor **119d** and the moisture detection label **100d**, which are connected in series, are connected to the first resistor **117d** in parallel.

The second resistors **119a**, **119b**, **119c**, and **119d** are set to have different values. When the moisture detection labels **100a** to **100d** get wet nearly simultaneously (for example, when the moisture detection device **110** is dropped in a puddle), the resistor portions **115a** to **115d** have different resistance values, whereby the Wheatstone bridge is non-equilibrium.

In the resistor portions **115a** to **115d**, the resistance values change according to the non-electrically-connected state (see FIGS. **1** and **4**) or the electrically-connected state (see FIGS. **5** and **6**) of the moisture detection labels **100a** to **100d**. When the moisture detection labels **100a** to **100d** are in the electrically-connected state (see FIGS. **5** and **6**), the resistance values of resistor portions **115a** to **115d** change, whereby the Wheatstone bridge is non-equilibrium.

Here, the non-balanced state of the Wheatstone bridge means a state where a current flows into the current detector **116** while the four resistor portions **R1** to **R4** constituting the Wheatstone bridge do not have the relation of $R1/R2=R3/R4$.

The moisture detection device **110** includes the current detector **116** as the detection means. The current detector **116** connects a connection line between the resistor portions **115a** and **115b** to a connection line between the resistor portions **115c** and **115d**. The current detector **116** is connected to a switch **113** as power shutoff means. The switch **113** is connected to a main circuit **112** of an electronics device **200** to which the moisture detection device **110** is mounted (see FIG. **18**). The main circuit **112** includes a CPU (control means) **200A**, a memory (storage means) **200B**, a communication circuit (not shown) such as a speaker.

The moisture detection device **110** further includes a battery **111** for power supply. The battery **111** connects the connection line between the resistor portions **115a** and **115d** to the connection line between the resistor portions **115b** and **115c**.

The battery **111** may be used as a battery for the electronics device **200**.

The switch **113** is connected between the battery **111** and the main circuit **112**. Accordingly, when the switch **113** is open, power of the battery **111** is not supplied to the main circuit **112**.

(Moisture Detection Device Action)

An action of the moisture detection device **110** shown in FIG. **12** is described based on FIGS. **13** and **14**. The moisture detection device **110** using the Wheatstone bridge that causes a current to flow when a resistant balance is lost, in which the current detector **116** detects changes in resistant values of the resistor portions **115a** and **115b**.

FIG. **13** is a drawing explaining an operation of the current detector **116**. The current detector **116** detects a current (**I**) from the Wheatstone bridge and then sets a switch control output voltage value to be output to the switch **113** to **0V** ("L" signal) (see FIG. **13**). Whereas when the current detector **116** does not detect the current (**I**) from the Wheatstone bridge, the switch control output voltage value to be output to the switch **113** is set to **1V** ("H" signal) (see FIG. **13**).

FIG. **14** is a drawing explaining an operation of the switch **113**. The switch **113** shown in FIG. **12** includes a control terminal **113A** to which the current detector **116** is connected. When the "H" signal is input to the control terminal **113A** from the current detector **116**, the switch **113** is turned on (a

state indicated by the real line of FIG. 12) and power of the battery 111 is supplied to the main circuit 200.

On the other hand, when the "L" signal is input to the control terminal 113A from the current detector 116, the switch 113 is turned off (a state indicated by the imaginary line of FIG. 12) to interrupt the voltage circuit of the battery 111. As a result, power is not supplied to the main circuit 200.

Since the moisture detection device 110 uses the Wheatstone bridge, when no moisture adheres to the moisture detection labels 100a to 100d (the non-electrically-connected state shown in FIGS. 1 and 4), the resistor portions 115a to 115d are in the balanced state. Therefore, the current detector 116 detects no current, and the switch is ON. Note that the moisture detection method using the moisture detection label 10 described based on FIGS. 1 and 4 to 6 is applied to the moisture detection device 110.

On the other hand, when moisture adheres to any of the moisture detection labels 100a to 100d (the electrically-connected state shown in FIGS. 5 and 6), a current flows between the seals 100 in the electrical connection state and the resistant portions 119 (any of the resistors 119a to 119d), whereby any of the resistance values of the resistor portions 115a to 115d) changes.

Accordingly, the Wheatstone bridge is non-equilibrium, and a current flows into the current detector 116. At this time, the current detector 116 outputs the "L" signal to the control terminal 113A of the switch 113 to turn the switch 113 OFF from ON. When the switch 113 is turned off, the power supply to the main circuit 112 from the battery 111 is shut off.

Note that in the moisture detection device 110, by visually identifying the moisture detection labels 100, it is possible to specify which detection seal gets wet in water.

According to the construction of this exemplary embodiment, power supply to the main circuit 112 is immediately shut off in conjunction with the moisture-adhesion states of the moisture detection labels 100a to 100d (the electrically-connected state shown in FIGS. 5 and 6), thereby making it possible to prevent a short circuit or the like from being caused by moisture adhesion to the main circuit 112. Therefore, according to this exemplary embodiment, generation of failure due to exposure to water or the like can be prevented.

Also, the moisture detection device 110 has the construction using the four moisture detection labels 100, thereby providing the moisture detection labels 100 at plural locations of the electronics device. Accordingly, adhesion of water to the electronics device can be detected reliably, and the location of the adhesion of water can be specified. Further, according to this exemplary embodiment, even when the four moisture detection labels 100 are arranged, only one detection circuit (the current detector 116) is provided, so the construction can be preferably simplified and the mounting area may be preferably set small.

FIG. 15 shows a moisture detection device according to a second exemplary embodiment of the present invention. Note that in the construction of the second exemplary embodiment, parts corresponding to those of FIG. 12 are denoted by the same reference numerals in FIG. 15, and a detailed description thereof is omitted. In the moisture detection device 110 of this exemplary embodiment, an output terminal of the current detector 116 is connected to the CPU 200A of the electronics device 200, and the CPU 200A is connected to the switch 113. Other constructions are the same as those of the exemplary embodiment shown in FIG. 12.

Next, a power shutoff method of this exemplary embodiment is described based on FIG. 16. This power shutoff method is used for the moisture detection labels 100 that include the patterns having at least a pair of detection terminals

provided on the substrate having the front surface insulated and formed between the detection terminals, and contain the water-dispersible and conductive paint, in which an electrical connection state between the detection terminals is detected, and when the electrical connection therebetween is detected, power to the main circuit 112 is shutoff.

Referring to FIG. 16, a processing relating to a power shutoff mode in the electronics device 200 is described. Here, the processing (power shutoff mode) in the electronics device 200 is represented by a flow chart of FIG. 16 executed in the CPU 200A of the electronics device 200 shown in FIG. 15. Programs thereof are previously stored in a program area of the memory 200B (see FIG. 15).

As shown in FIG. 16, in a step 100, the CPU 200A judges whether or not the moisture detection labels 100 indicate a water-adhesion state (the electrically-connected state shown in FIGS. 5 and 6), based on the "L" signal from the current detector 116. When YES in a step 100, that is, it is judged that the moisture detection labels 100 are in the electrical connected state, the CPU 200A judges in a step 102 whether there is data that has not been recorded in the memory 200B yet.

When YES in the step 102, that is, it is judged that there is data that has not been recorded therein yet, the CPU 200A records in a step 104 the data in the memory 200B. After the processing in the step 104, the CPU 200A causes a speaker (alert means) (not shown) in a step 106 to output alert data such as an alert sound or message for a predetermined time. Note that in this case, a display 202 of the electronics device 200 (see FIG. 18) may be caused to display an alert message, etc.

After the processing in the step 106, the CPU 200A turns the switch 113 OFF from ON to thereby turn off the power in a step 108. On the other hand, when NO in a step 102, that is, it is judged that all data is recorded in the memory 200B, the processing advances to the step 106 where the CPU 200A causes the speaker to output the alert data and to turn off the power in the step 108. Other action effects are the same as those of the exemplary embodiment of FIG. 12. Note that in this exemplary embodiment, the power may be turned off without recording data in the memory 200B or causing the speaker or the like to output alert data.

FIG. 17 shows a moisture detection device according to a third exemplary embodiment of the present invention. Note that in the construction of the third exemplary embodiment, parts in FIG. 17 corresponding to those of FIG. 12 are denoted by the same reference numerals and a detailed description thereof is omitted.

A moisture detection device 120 shown in FIG. 17 includes the battery 111, the main circuit 112, the switch 113, the moisture detection label 10, an output terminal 121 of a regulator, and resistors 123 and 125. In the moisture detection device 120, the switch 113 is connected in series between the battery 111 and the main circuit 112. Here, the moisture detection label mounted to the moisture detection device 120 is, for example, the moisture detection label 10 shown in FIG. 1.

Then, the resistor 123 is connected in series between the output terminal 121 of the regulator and the switch 113. Further, the moisture detection label 10 and the resistor 125 are connected between the resistor 123 and the switch 113.

In the moisture detection device 120, when no moisture adheres to the moisture detection label 10 (the non-electrically-connected state shown in FIGS. 1 and 4), the control terminal 113A of the switch 113 is pulled up by the output terminal 121 of the regulator (power source). Accordingly, the switch 113 is ON, whereby power is supplied from the battery 111 to the main circuit 112.

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On the other hand, when moisture adheres to the moisture detection label 10 (the electrically-connected state shown in FIGS. 5 and 6), a current is pulled down to GND (ground) through the resistor 125. Thus, a voltage is not applied to the control terminal 113A of the switch 113, and the switch 113 is turned OFF from ON, whereby power supply from the battery 111 to the main circuit 112 is shutoff.

Also, in the moisture detection device 120 shown in FIG. 17 too, similar to the case of the moisture detection device 110 shown in FIG. 12, the electrical connection state of the moisture detection label 10 can be detected based on a resistor value change. Then, based on the detection result, power supply to the main circuit 112 can be shutoff.

Also, the moisture detection device 120 can detect adhesion of water with a still simpler construction than the moisture detection device 110 shown in FIG. 12.

The above detection devices are preferably used for electronics devices having a data storage function, such as a cell phone (mobile terminal), a portable personal computer, PDA (Personal Digital Assistant), and various cameras.

(Electronics Device Construction)

Electronics devices according to this exemplary embodiment (see FIGS. 18 and 19) have one of the moisture detection devices 110, 110A, and 120 shown in FIGS. 12, 15, and 17. Note that the electronics device in this exemplary embodiment is a cell phone for description. Also, the electronics device in this exemplary embodiment is described as an example having the moisture detection device 110 shown in FIG. 12 mounted thereto.

The electronics device includes: a device main body having a power source; the moisture detection label that includes the patterns having at least a pair of detection terminals arranged on the device main body, provided on the substrate having the insulated front surface, and formed between the detection terminals, and contain the water-dispersible and conductive paint; and detector arranged on the device main body, for detecting an electrical connection state between the detection terminals of the moisture detection label.

FIG. 18 is a perspective view when a foldable cell phone 200 is opened. FIG. 19 is an exploded perspective view of the foldable cell phone 200 shown in FIG. 18.

As shown in FIG. 18, the display portion (device main body) 202 of the mobile phone 200 and an operation portion (device main body) 201 are openable and closable via a hinge portion. As shown in FIG. 19, the operation portion (device main body) 201 includes an upper case 204 and a lower case 205, which are formed like a shallow box. The operation portion 201 accommodates a print wiring board 214. The upper case 204 includes a predetermined number of function buttons 219 and push-button dial 218.

The display portion 202 includes an upper case 206 and a lower case 207 similarly to the operation portion 201. The display portion 202 accommodates a print wiring board 215. The upper case 206 includes a display 220 as alert means.

The print wiring board 214 and the print wiring board 215 are connected through a flexible board 216. The hinge portion 203 is composed of hinge barrels 208 and 211, half hinge barrels 209, 210, 212, and 213, and a hinge unit 217.

In this exemplary embodiment, the moisture detection labels 100a to 100d are arranged at four locations of the print wiring board 214. For example, the moisture detection labels 100a to 100d are respectively arranged near the hinge portion 203 and its opposite side through which a liquid such as water easily enters.

In this exemplary embodiment, the plural moisture detection labels 100, for example, four seals, are arranged. Thus, it is possible to specify which location of the cell phone 200 got

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wet in water by visually identifying the moisture detection labels 100. Note that other actions and effects are the same as those of the moisture detection device shown in FIG. 12, so the detailed description thereof is omitted.

Note that in this exemplary embodiment, the arrangement locations and number of the moisture detection labels 100 can be changed appropriately. For example, the seal may be arranged on a front surface of the lower case 205. Also, as shown in FIG. 20, in the mobile phone 200, the moisture detection labels 100 may be arranged at only two locations near the hinge portion 203 of the print wiring board 214.

Further, in the mobile phone 200, the CPU 200A (see FIG. 12) may record data such as date and time when the cell phone 200 got wet, in the memory 200B (see FIG. 12).

In this case, the data such as date and time when the cell phone 200 got wet is read from the memory 200B to check whether the cell phone 200 got wet, and what date and time it happened, for example. Therefore, when a failure occurs in the mobile phone 200, it is possible to judge: whether or not the failure caused by adhesion of water; or the failure is caused by user's mishandling or caused by a manufacturer by having the cell phone 200 got wet before its sale.

Patterns of combination in the present invention may be a pattern of the above exemplary embodiments or combining two or more examples among the above exemplary embodiments.

The flow of the processing program described in the above exemplary embodiments (see FIG. 16) is merely an example and may be appropriately changed within the scope of the present invention.

Further, it is noted that the inventor's intent is to retain all equivalents of the claimed invention even if the claims are amended during prosecution.

What is claimed is:

1. A moisture detection label, comprising:

a base material;

at least a pair of detection terminals provided on the base material; and

a pattern of water-dispersible and conductive paint provided on the front surface of the base material and formed between the detection terminals, wherein the base material has grooves across the detection terminals,

wherein the water-dispersible and conductive paint is a conductive electrodeposition paint comprising an ionic substance with ink,

wherein when moisture does not adhere to the pattern, there is no electrical connection between the detection terminals, and

wherein when moisture adheres to the pattern, the pattern swells or disperses to form an electrical connection between the detection terminals.

2. The moisture detection label according to claim 1, wherein the pattern swells by absorbing moisture and is dispersed over the front surface of the base material toward the detection terminals.

3. The moisture detection label according to claim 1, wherein two or more of the patterns are provided between the detection terminals.

4. The moisture detection label according to claim 3, wherein the two or more of the patterns are arranged in a lattice pattern.

5. The moisture detection label according to claim 1, wherein each of the detection terminals is provided on an outer periphery of the base material in a manner that the detection terminals are opposed to each other.

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6. The moisture detection label according to claim 1, wherein the base material is formed into a sheet-like shape, and the detection terminals are provided from the front surface to a rear surface of the base material.

7. A moisture detection device, comprising:

a moisture detection label that has at least a pair of detection terminals and a pattern,

wherein the detection terminals are provided on a base material, the pattern comprises water-dispersible and conductive paint and is provided on the front surface of the base material and formed between the detection terminals, and the base material has grooves across the detection terminals; and

a detector that detects an electrical connection state between the detection terminals of the moisture detection label,

wherein when moisture does not adhere to the pattern, there is no electrical connection between the detection terminals, and

wherein when moisture adheres to the pattern, the pattern swells or disperses to form an electrical connection between the detection terminals.

8. The moisture detection device according to claim 7, wherein the detector includes a Wheatstone bridge, and the Wheatstone bridge has a nonequilibrium when the detection terminals are electrically connected.

9. The moisture detection device according to claim 8, wherein, the Wheatstone bridge includes resistors connected in series to one of the detection terminals of the moisture detection label, and

wherein, each resistor has a resistance value different from one another.

10. The moisture detection device according to claim 7, wherein the pattern swells by absorbing moisture and is dispersed over the surface of the base material toward the detection terminals.

11. A moisture detection method comprising:

providing a moisture detection label that includes at least a pair of detection terminals and a pattern, the detection terminals being provided on a base material, the pattern containing water-dispersible and conductive paint and being formed between the detection terminals, whereby the paint swells by absorbing moisture to thereby disperse toward the detection terminals; and

detecting an electrical connection state caused between detection terminals through the dispersed paint, and wherein the water-dispersible and conductive paint is a conductive electrodeposition paint comprising an ionic substance with ink,

wherein when moisture does not adhere to the pattern, there is no electrical connection between the detection terminals, and

wherein when moisture adheres to the pattern, the pattern swells or disperses to form an electrical connection between the detection terminals.

12. The moisture detection method according to claim 11, wherein an electrical connection state between the detection terminals is detected in a Wheatstone bridge, and the Wheatstone bridge has a nonequilibrium state when the detection terminals are electrically connected.

13. The moisture detection method according to claim 12, wherein, in the Wheatstone bridge, resistors connected in series to one of the detection terminals of the moisture detection label each has a resistance value different from one another.

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14. An electronics device, comprising:

a device main body having power source;

a moisture detection label that is provided on the device main body, and has at least a pair of detection terminals and a pattern,

wherein the detection terminals are provided on a base material, the pattern comprises a water-dispersible and conductive paint and is provided on the surface of the base material and is formed between the detection terminals, and the base material has grooves across the detection terminals; and

detector that is provided on the device main body and detects an electrical connection state between the detection terminals of the moisture detection label, and

wherein the water-dispersible and conductive paint is a conductive electrodeposition paint comprising an ionic substance with ink,

wherein when moisture does not adhere to the pattern, there is no electrical connection between the detection terminals, and

wherein when moisture adheres to the pattern, the pattern swells or disperses to form an electrical connection between the detection terminals.

15. The electronics device according to claim 14, further comprising:

power shutoff means for shutting off power based on the electrical connection state detected by the detector.

16. The electronics device, according to claim 15, further comprising:

control means for causing storing means to store data before the power shutoff means shuts off power.

17. The electronics device according to claim 14, further comprising:

warning means for warning of adhesion of water based on the electrical connection state detected by the detector.

18. A power shutoff method used in a moisture detection label that includes at least a pair of detection terminals and a pattern, the detection terminals being provided on a base material, the pattern containing water-dispersible and conductive paint and being formed between the detection terminals, the power shutoff method comprising:

detecting an electrical connection state between the detection terminals; and

shutting off power in a case where it is detected that the detection terminals are electrically connected, and

wherein the water-dispersible and conductive paint is a conductive electrodeposition paint comprising an ionic substance with ink,

wherein when moisture does not adhere to the pattern, there is no electrical connection between the detection terminals, and

wherein when moisture adheres to the pattern, the pattern swells or disperses to form an electrical connection between the detection terminals.

19. The power shutoff method according to claim 18, further comprising:

causing storing means to store data before shutting off power, in a case where it is detected that the detection terminals are electrically connected.

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20. The power shutoff method according to claim 18, further comprising:

causing warning means to warn of adhesion of water before shutting off power, in a case where it is detected that the detection terminals are electrically connected.

21. The moisture detection label according to claim 1, wherein the base material has an insulated front surface.

22. The moisture detection device according to claim 7, wherein the base material has an insulated front surface.

23. The electronic device according to claim 14, wherein the base material has an insulated front surface.

24. The moisture detection label according to claim 1, wherein the pattern is configured to disperse upon contact with water.

25. The moisture detection device according to claim 7, wherein the pattern is configured to disperse upon contact with water.

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26. The electronic device according to claim 14, wherein the pattern is configured to disperse upon contact with water.

27. The power shutoff method according to claim 18, wherein the pattern is configured to disperse upon contact with water.

28. The moisture detection label according to claim 1, further comprising a processor for determining when there is an electrical connection resulting from the swelling or dispersion of the pattern.

29. The moisture detection device according to claim 7, further comprising a processor for determining when there is an electrical connection resulting from the swelling or dispersion of the pattern.

30. The electronic device according to claim 14, further comprising a processor for determining when there is an electrical connection resulting from the swelling or dispersion of the pattern.

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